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(54) CEMENT SOLIDIFIED MATERIAL COMPRISING BURNED ASH OF SEWAGE SLUDGE AS RAW MATERIAL, GRADED GRAIN TREATING MATERIAL USING THE CEMENT SOLIDIFIED MATERIAL AND STABILIZATION TREATMENT

(57)Abstract:

PROBLEM TO BE SOLVED: To simply recycle burned ash of sewage sludge without a specific treatment by adjusting the carbon content of burned ash of sewage sludge to a specific value or smaller than it, mixing the burned ash with cement in a specific ratio, adding water to the mixture, solidifying and making a uniaxial compressive strength in a specific range.

SOLUTION: The carbon content of burned ash of sewage sludge is adjusted to  $\leq 3$  wt.%. The burned ash of sewage sludge is mixed with cement in the weight ratio of 1:1 to 1:3 and a proper amount of water and solidified to give a cement solidified material having 100-200 kgf/cm<sup>2</sup> uniaxial compressive strength (28 day material age). When the cement solidified material is ground to give a granular aggregate and the granular aggregate is mixed with Fe lime and natural soil, the granular aggregate is embedded in a matrix of Fe lime treated soil and a hydrate by a Fe lime-based stabilizer is formed on a contact face between the surface of the granular aggregate and the matrix. Consequently the strength of a stably treated roadbed is improved by the increase of bond strength and frictional resistance on the contact face.

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**CLAIMS**

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**[Claim(s)]**

[Claim 1] The cement solidification object which uses as a raw material sludge incinerated ash characterized by making it the carbon content of sludge incinerated ash become below 3(weight) %, having mixed this sludge incinerated ash and cement by the weight ratio, and it having mixed incinerated ash:cement at a rate of 1:1-1:3, and adding the water of optimum dose, having made it solidify, and making unconfined compressive strength into 100 - 200 kgf/cm<sup>2</sup> (age 28 days).

[Claim 2] Grain tone processing material characterized by mixing Fe lime system stabilizer which becomes the mixture of the granular aggregate which crushed the cement solidification object of claim 1, and natural soil from the impalpable powder and slaked lime of an iron oxide.

[Claim 3] It is the stabilization method characterized by laying a base course by the grain tone processing material of claim 2, and each granular aggregate being in the condition that embedding was carried out by the matrix of Fe lime system processing soil, after a compaction.

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**DETAILED DESCRIPTION**


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[Detailed Description of the Invention]

[0001]

[Field of the Invention] This invention about the sludge incinerated ash by which a byproduction is carried out by terminal down stream processing of city sewage When a carbon component uses the following [ a constant rate ] and it is made to have the above reinforcement to some extent about the cement solidification object which mixed cement with sludge incinerated ash and was solidified This is made into a construction material etc. as it is, or it uses as the granular aggregate for stabilization, and is related with the reuse method of the trash of the environmental enterprise of sewage treatment.

[0002] The amount of the sludge generated with the spread of sewerage in recent years is also increasing rapidly, and in order to process this sludge in large quantities, ED by the melting system is furthered from the field of use to a construction material. That is, the inorganic substance in sludge is fused in the state of a 1300 degrees C - 1400 degrees C elevated temperature, and the easy molten slag of construction-material-izing is generated.

[0003] However, the physical properties changed sharply with the approaches of taking out, and molten slag needed to promote crystallization by heat insulation (heat release is stopped and annealed by temperature control), or reheating (fixed time amount care of health of the slag of water cooling and air cooling is carried out in a 900 degrees C - 1000 degrees C temperature requirement), in order to be satisfied with independent of the reinforcement which bears grain refining by the compaction as base course material etc. Since mass production method is difficult, this molten slag does not suit the purpose of extensive processing of sludge, either, while it is expensive and unusable from a cost side in a general road enterprise.

[0004]

[Description of the Prior Art] By the way, from the former, the effectiveness is accepted widely and the treated soil which added lime and cement as foundation stabilization, such as a base course, has been adopted. And the applicant of this application develops the soil stabilizer ("Fe lime" may be called below) which mixed the impalpable powder of an iron oxide which heightened this effectiveness further, and which carries out a byproduction to lime (calcined lime, slaked lime, and limestone powder) at the time of iron manufacture. Moreover, processing soil which mixed natural soil etc. to this ("Fe liming soil" may be called below) Research which has and improves a soft ground has been done for years.

[0005] And as a result of research, the artificer of this application developed and did patent application of the soil stabilizer which mixed sludge incinerated ash and Fe lime paying attention to being similar with the major component about a reaction mechanism in case the major component presentation of sludge incinerated ash is the above-mentioned Fe lime (SiO<sub>2</sub>, aluminum 2O<sub>3</sub>, Fe<sub>2</sub> O<sub>3</sub>, etc. being common) (refer to JP,8-3552,A).

[0006] The sludge incinerated ash by which a byproduction is carried out in the Fukuoka, Fukuoka sewage disposal plant in the above-mentioned invention is used, and effectiveness which is indicated by this application is checked. However, as shown in table 1 \*\*, when the sludge incinerated ash by which a byproduction is carried out after that in the Saga, Saga sewage purification pin center, large was used, and the incinerated ash ("Saga-shi A" may be called below) concerned was used, there is not only no effectiveness in strong improvement, but it became clear to check the reaction mechanism of Fe liming soil. That is, the CBR reinforcement of the processing soil which added and mixed Fe lime stabilizer of 6.5(weight) % decreases in inverse proportion to the addition of the incinerated ash to farmland in the soil which added the incinerated ash concerned to farmland and carried out quality-of-the-material adjustment.

[0007] Moreover, Table 2 was a result at the time of replacing the same experiment with Fe lime and usually using cement, and when the incinerated ash (Saga-shi A) concerned as well as Fe liming soil was added also in cement treated soil, there is not only no effectiveness in strong improvement, but it became clear to check a reaction mechanism.

[0008]

[Problem(s) to be Solved by the Invention] Then, the reason which analyzes the component of the sludge incinerated ash of Saga-shi A and the sewage incinerated ash of Fukuoka-shi, and such a difference produces was examined. the carbon content ("carbon" may be called below) considered that it will depend a most different point on incomplete combustion if Table 3 is as a result of [ of the sludge incinerated ash of Saga-shi A ] component analysis and carries out comparison examination with the component result (refer to [ of JP,8-3552,A / Table 1 ]) of the sludge incinerated ash of Fukuoka-shi -- a 8.5(weight) % thing -- it turned out that it is contained with the high value.

[0009] Although this carbon was granulated and it was contained in incinerated ash, since it was a very fine particle and was the quality of organic of the condition of the soot which becomes the raw material of Japanese ink when unfolded by the fingertip, it was thought that it was the inhibition factor of the reaction mechanism of a lime system or a cement system. In addition, the physical property of Table 4 and the object soil (farmland) which used Table 5 in the experiment by reaching, and a chemical presentation are shown.

[0010] Then, the following results were brought, when it made laying temperature in a furnace into 800 degrees C and 1200 degrees C with the electric furnace and experimented by changing burn time for 10 minutes, for 30 minutes, and for 60 minutes, in order to remove the carbon of the sewage-sludge incinerated ash of Saga-shi A.

[0011] When laying temperature was made into 800 degrees C, and it returned to the room temperature by combustion for 10 minutes, a great portion of carbon remained as it was, its whole color changes hardly and was also black but, and for 30 minutes, by combustion, when a great portion of carbon burned and returned to the room temperature, it changed into the condition that brown and a black particle were mixed. Moreover, for 60 minutes, in combustion, even if most carbon burned and returned to the room temperature, it presented the same light brown as the incinerated ash of Fukuoka-shi used as an example of a comparison as the whole, and changed into the condition that very a small amount of black particle is mixed.

[0012] It changed into the condition of having collected on the pars basilaris ossis occipitalis of a container in the state of melting, remained in a black color with the great portion of carbon as it is when laying temperature was made into 1200 degrees C and it returned to the room temperature in the combustion during 10 minutes, melting-ization advanced much more in the combustion during 30 minutes, vitrification progressed in part, and it united with the pars basilaris ossis occipitalis of a container, and adhered. Moreover, when melting-izing and vitrification advanced further and returned to the room temperature in combustion for 60 minutes, it was in the situation which unites with a container and is damaged.

[0013] The carbon content (carbon) was 0.07(weight) %, and since the thing for [ burn time ] 60 minutes was considered that carbon is removed most with the laying temperature of 800 degrees C from the result of the above viewing, when component analysis of this was performed, although there was no change with other big components as compared with Table 3, it was checked that the carbon content is decreasing extremely as shown in Table 6.

[0014] Next, the experiment about the effect affect the CBR reinforcement of Fe liming soil at the time of mixing to farmland the incinerated ash which carried out combustion processing, and carrying out quality-of-the-material adjustment with this electric furnace was conducted. Although the result was shown in Table 7, it has checked that it could use as a stabilizer of Fe liming soil by carrying out combustion processing and removing the carbon contained in sewage-sludge incinerated ash.

[0015] Next, various experiments were conducted for the purpose of improving an operating method in the currently possessed facility of the Saga sewage-purification pin center,large, and decreasing a carbon content (carbon). although it is markedly alike and there is a carbon content (carbon), when they compare the 800 degrees C of the above-mentioned electric furnaces, and 0.07(weight) % in the combustion during 60 minutes by 2.28(weight) %, although Table 8 shows the sludge incinerated ash ("Saga-shi B" may be called below) component analysis result obtained as a result, if it compares the incinerated ash of conventional Saga-shi A, it will decrease to about 1/4. [ many ]

[0016] The experiment about the effect affect the CBR reinforcement of Fe liming soil at the time of mixing the sludge incinerated ash of this Saga-shi B to farmland, and carrying out quality-of-the-material adjustment was conducted. The reinforcement effectiveness of the processing soil by using the incinerated ash of this Saga-shi B as quality-of-the-material adjustment material of the farmland of Fe liming soil etc., although that result is shown in Table 9 is \*\*\*\*\* , when there is nothing and it becomes the inhibition factor of a reaction mechanism rather. Therefore, it turned out that it is impractical to use the sludge incinerated ash of a carbon content of this amount (a little more than 2%), mixing with Fe lime as it is.

[0017] Then, in the Saga sewage purification pin center,large, the experiment which lowers the moisture content of a cake further using flocculants, such as Pori ferric chloride, gathers combustion efficiency, and performs combustion removal of content carbon was conducted. Although Table 10 shows the component analysis result of the sludge

incinerated ash ("Saga-shi C" may be called below) obtained as a result, the 800 degrees C of the above-mentioned electric furnaces which show a carbon content (carbon) in Table 3 by 0.21(weight) %, and the thing which approaches 0.07(weight) % in combustion fairly for 60 minutes were obtained.

[0018] Although it turned out that it is possible to carry out considerable reduction of the carbon content also in a currently possessed facility by the above-mentioned experiment, if the actual operating status in a facility etc. is taken into consideration, it is next to impossible in this time to decrease carbon to the condition of Saga-shi C in practice, and it is practical to make it work within the limit of the condition about Saga B.

[0019]

[Means for Solving the Problem] Then, various experiments were conducted by the premise whether what solidified this incinerated ash into cement can use it as the granular aggregate or other construction materials instead of using the sludge incinerated ash of the carbon content (a little more than 2%) about Saga B, mixing with Fe lime as it is, that practicality was checked and this invention was completed so that it might explain in full detail below.

[0020] That is, make it the carbon content of sludge incinerated ash become below 3(weight) %, mix this sludge incinerated ash and cement by the weight ratio, and it mixes incinerated ash:cement at a rate of 1:1-1:3, and add the water of optimum dose, it is made to solidify, and the cement solidification object which uses sludge incinerated ash concerning this invention as a raw material makes unconfined compressive strength 100 - 200 kgf/cm<sup>2</sup> (age 28 days).

[0021] Moreover, the grain tone processing material concerning this invention mixes Fe lime system stabilizer which becomes the mixture of the granular aggregate which crushed the above-mentioned cement solidification object, and natural soil from the impalpable powder and slaked lime of an iron oxide.

[0022] On the other hand, the stabilization method concerning this invention lays a base course by the above-mentioned grain tone processing material, and it is made for each granular aggregate to be in the condition that embedding was carried out by the matrix of Fe lime system processing soil, after a compaction.

[0023]

[Function] The sludge incinerated ash which pressed down carbon (carbon) below to the constant rate carries out the chemical reaction near Fe lime, and if this is mixed with cement and it is made to solidify, it will serve as a cement solidification object of the lightweight porosity of low strength comparatively.

[0024] And when the granular aggregate which crushed this is mixed and used for Fe lime and natural soil, embedding of the granular aggregate will be carried out by the matrix of Fe liming soil, the hydrate by Fe lime system stabilizer will be generated by the contact surface of the front face of the granular aggregate, and a matrix, and the reinforcement of a stabilized base will be increased by the increment in the bonding strength in the contact surface, and frictional resistance.

[0025]

[The mode of implementation of invention] High reinforcement like [ in the case of using the cement solidification object of this invention as granular base course material independently as the granular aggregate ] is not needed. However, while conducting the various following experiments in order to clarify this since the reinforcement of the cement solidification object for manufacturing the reinforcement of the granular aggregate and the granular aggregate was unknown, based on the various experiences of an applicant's past, a practically usable cement solidification object, the reinforcement of the granular aggregate, etc. were determined.

[0026] First, the experiment about a combination setup of the cement solidification object which uses incinerated ash as the main raw material was conducted, and the experiment about a combination setup of Fe lime system stabilized base material ("grain tone Fe processing material" may be called below) which mixed the granular aggregate which subsequently carried out mechanical crushing of some kinds of cement solidification objects based on this combination setup was conducted.

[0027] In addition, Fe lime method of construction as used in the field of this application makes it the criterion to build the stabilization layer (restricted layer of impermeability) which added and mixed Fe lime stabilizer as shown in natural soil (northern part Kyushu the Masa soil and South Kyushu milt etc.), such as sandy loam available the present location or near a site on a weak subgrade thru/or sandy clay, in Table 11, as shown in drawing 1.

[0028] It is coming as applying grain tone Fe processing material to a base course for the purpose of improving the endurance by fatigue of this standard type of granular base course. Since the granular aggregate by construction and demolition waste with which we excel in a water resisting property, periodic-damping nature, etc. and with which we are anxious about grain refining as independent granular base course material is utilized at the high rate of 40 - 50 (weight) %, this is applied to the base course of waterproof pavement of the low flat ground to which the underground-passage section and the road of a grade separation will be in a submersion-under-water condition as shown in drawing 2, or reinforcement pavement of an urbanization area. The method of using the granular aggregate which crushed the

cement solidification object which sludge incinerated ash of this invention raw material as reinforcing materials of grain tone Fe processing material does research and development in the experiential technique of these many years as the base.

[0029] First, the sludge incinerated ash of Saga-shi B of carbon content about 2.3 (weight) % and the sludge incinerated ash of Saga-shi C of carbon content about 0.2 (weight) % were used, the mixing ratio of incinerated ash and cement was changed, and the cement solidification object was created. Moreover, by increasing the granularity of the front face of the granular aggregate, the matrix after a compaction and improvement of the reinforcement of the grain tone Fe processing layer by increase of the frictional resistance in an aggregate front face were expected, and the cement solidification object was created also about what mixed the screenings (SC) of natural \*\*\*\* at a rate of 5:2 by the dry weight ratio to incinerated ash. The both result is expressed to Table 12 - 15. moreover, drawing 3 and drawing 4 are resembled and the relation between a cement content per unit volume of concrete and unconfined compressive strength (age 28 days) is shown.

[0030] Even if it will use which incinerated ash if cement is mixed with incinerated ash at a rate of 1:1 so that clearly from Table 12 and 14, it is unconfined-compressive-strength 100 kgf/cm<sup>2</sup>. It turns out that it is possible to create the cement solidification object of extent. And if the amount of cement is increased, unconfined compressive strength will also rise along with it. Moreover, also when the screenings of natural \*\*\*\* are mixed with an incinerated ash simple substance at a rate of 5:2 to incinerated ash so that clearly from drawing 3 and drawing 4, there is not much big difference in respect of improvement on the strength. Although the screenings of natural \*\*\*\* are effective if it is going to obtain the cement solidification object of high reinforcement, considering the purpose of this invention, not much high reinforcement is not required and it is more effective to utilize nearby incinerated ash many from it.

[0031] therefore, about the cement solidification object used for the experiment about a combination setup of the following grain tone Fe processing material From a strong field, the unconfined compressive strength on age the 28th is 50, 100, 150, and 200 kgf/cm<sup>2</sup> with an incinerated ash simple substance. Four kinds Moreover, it experimented by one sort of a total of five kinds from which it is what mixed the screenings of natural \*\*\*\* with incinerated ash at a rate of 5:2 from the field of improvement of the frictional resistance by increasing the granularity on the front face of the aggregate, and the unconfined compressive strength on age the 28th serves as 100 kgf/cm<sup>2</sup>.

[0032] the purpose of experimental research here -- an outline -- it can summarize as follows. That is, in the grain tone Fe processing material after a compaction, it is asking for an aggregate size range which grain refining's is prevented [ size range ] and has ten to seven or less coefficient of permeability (cm/s) secured, and the rate of basic combination by carrying out embedding of the mixed granular aggregate of low strength if independent, to the extent that it is inapplicable to base course material completely by the matrix of Fe lime system processing material.

[0033] It is more specifically as follows.

\*\* About the grain tone Fe processing material which mixed the granular aggregate by the incinerated ash cement solidification object with which four kinds of reinforcement differs in farmland, ask for the relation between the reinforcement of the granular aggregate, and CBR reinforcement about each age, and ask for the optimal reinforcement of a cement solidification object.

\*\* Display the value about the grain tone Fe processing material which mixed the granular aggregate of the cement solidification object (unconfined-compressive-strength 100 kgf/cm<sup>2</sup> on age the 28th) which mixed the screenings of natural \*\*\*\* at a rate of 5:2 (dry weight) to incinerated ash on the above-mentioned related Fig., and perform evaluation about the screenings of natural \*\*\*\*.

\*\* Instead of the granular aggregate by the above-mentioned cement solidification object, as an example of a comparison, when natural \*\*\*\* is applied, ask for the CBR reinforcement in each age about the case where Fe lime stabilizer is added to a farmland simple substance, and perform the case where it is based on this invention, and comparison examination.

\*\* Check coarse-grain-izing grading of aggregate on the front face of the granular aggregate by the cement solidification object immediately after tamping thru/or in its first stage according to the condensation-ized operation based on the ion exchange reaction of Fe lime system stabilizer in this invention. In order to verify this, when the difference in the reinforcement of a cement solidification object or natural \*\*\*\* is applied by performing sieve analysis of the aggregate immediately after tamping and about the specimen on age the 4th, comparison examination with the case where Fe lime stabilizer is not added is performed.

\*\* While conducting the sample crushing adjustment approach \*\*\*\*\* comparative experiments in sieve analysis, perform particle size analysis at the time of distributing granulation using a dispersant (hexametaphosphoric acid sodium), and verify effectiveness of this invention again.

[0034] And as a preliminary test, in order to ask for the size range and the rate of basic combination of grain tone Fe

processing material The granular aggregate (curve which connects the grain-size range value of M-25 shown in Table 17) by natural \*\*\*\* shown in the Masa soil of Table 4 and 5 in Table 16 To the mixture mixed by 0, 20, 40, 60, and 80,100(dry weight) %, the standard Fe lime of 6.0(dry weight) % was added, and a tamping trial, California bearing ratio test, and water permeability test of processing soil were performed.

[0035] In addition, having used not a cement solidification object but standard \*\*\*\* which uses as a raw material sludge incinerated ash which is the object of this invention as the granular aggregate by this trial is based on the reason of two points as follows.

\*\* Since the specific gravity difference of the Masa soil and the granular aggregate by standard \*\*\*\* is 0.2 or less, the difference of dry density will mainly express whenever [ compaction / of the Masa soil as a matrix ], and the check of a result is easy.

\*\* Even if the amount of mixing of the granular aggregate increases and the granular aggregate receives the impact load by tamping directly, it is because there is no grain refining, so analysis is easy if it is standard \*\*\*\*.

[0036] Although Table 18 and Table 19 are tables of the Masa soil, the rate of mixing of the grain tone Fe processing material by standard \*\*\*\*, and a synthetic grain size, since the generation of the agglutination by the ion exchange reaction or a hydration compound by the stabilizer (Fe lime) affects grading of aggregate (Table 20 - 22 and drawing 5 - drawing 7 ), they are calculating by adding Fe lime here.

[0037] The result of Table 23 and drawing 8 - drawing 10 shows the following thing.

\*\* With the rate of mixing of the granular aggregate, and the relation of tamping dry density (however, the count of tamping class 67 time x three layers), although a consistency increases linearly along with the rate of mixing of the granular aggregate even in 50% even of rates of mixing, fall [ whether a consistency seldom increases and ] at 60% or more. Since there is no specific gravity difference in the Masa soil and the aggregate not much, if it becomes 60% or more of rates of aggregate mixing, the aggregate and the aggregate will contact, and this is considered because the compaction of a matrix is checked, although whenever [ compaction / of a matrix ] goes up with the aggregate at first.

\*\* With the rate of mixing, and the relation (submersion during after [ tamping ] four days) of CBR, although even 0% even of rates of mixing shows comparatively high reinforcement according to a reaction mechanism, with 20% of rates of mixing, it becomes high about twenty percent further, and at 40% of rates of mixing, although reinforcement becomes somewhat low, it shows a high value about about ten percent rather than 0% of rates of mixing. However, at 40% or more of rates of mixing, reinforcement falls linearly by the increment in the rate of mixing, and 100% (6% of 94% +Fe lime of standard \*\*\*\*) of rates of mixing shows a value lower than a granular aggregate independent case.

\*\* Although 0% (6% of 94% +Fe lime of Masa soil) of rates of mixing shows the value of  $5.5 \times 10^{-7}$  with the rate of mixing, and water penetration relation and 20% of rates of mixing shows a further a little low value with them, if the value of  $8.4 \times 10^{-7}$  is shown and the rate of mixing increases more than it, at 40% of rates of mixing, a coefficient of permeability will increase linearly. however, the granular aggregate which shows the value of  $8.0 \times 10^{-5}$  with 100% (6% of 94% +Fe lime of standard \*\*\*\*) of rates of mixing, and does not add Fe lime stabilizer -- it becomes a value very lower than the coefficient of permeability in the case of being independent.

[0038] From the result of the above-mentioned preliminary test, it is thought that the desirable size range and the rate of basic combination in this invention are as follows.

\*\* The minimum of the desirable size range in this invention serves as a grading curve of 60% of rates of aggregate mixing of drawing 11 , and an upper limit serves as a grading curve of 0% of rates of aggregate mixing similarly.

\*\* The rate of basic combination becomes 6.0% of combination of 40% of synthetic grain size shown in Table 18, i.e., [the 37.6% +Fe lime of 56.4% + granular aggregates of Masa soil].

Therefore, in the trial described below, it carried out on the basis of these size ranges and the rate of basic combination. Test procedure and the result are as follows. However, it sees from the result of above-mentioned drawing 8 - drawing 10 , and at 20% - 60% of rates of aggregate mixing, he can use and it is thought by 25% - about 45% that the best result is obtained.

[0039] 1) The granular aggregate which carried out mechanical crushing of the cement solidification object which uses sludge incinerated ash of adjustment this invention of the volume ratio by the adjustment 1-1 specific-gravity amendment by specific gravity and the coefficient of water absorption as a raw material has very small specific gravity compared with the usual aggregates, such as natural \*\*\*\*, as shown in Table 24, and a coefficient of water absorption is very large. As the grain tone Fe processing base course using this as the granular aggregate shows to Table 25, it is important to manage the volume of each ingredient to the volume of the whole grain tone Fe processing layer which amended the rate of combination by the specific gravity of the use aggregate, fastened, and was hardened. In addition, since this is similar to the fundamental description of an asphalt paving mixture being greatly influenced with the volume of the material of construction, the adjustment approach of the volume ratio by specific gravity amendment is

proportionate to the asphalt pavement outline.

[0040] 1-2) the adjustment to a coefficient of water absorption -- since the coefficient of water absorption is very high as shown in Table 24, in manufacture of the grain tone Fe processing material of this invention, beforehand, the granular aggregate by the cement solidification object of here performs sufficient water absorption, and mixes the granular aggregate by the surface desiccation saturation state. That is because there is the important purpose of supply of moisture indispensable to promotion of the agglutination by the ion exchange reaction by Fe lime system stabilizer in the front face of not only the purpose but the above-mentioned granular aggregate and the contact surface of a matrix which are only called adjustment of compaction moisture content. However, since all fundamental combination is performed by the dry weight percentage (%) here, if in charge of manufacture of processing material, based on the definition of the moisture content of soil, conversion measuring of the dry weight is carried out at humid weight.

[0041] 2) The Masa soil shown in the test-method table 4 and Table 5 of grain tone Fe processing material (however, thing adjusted to the grain size of Table 18), The cement solidification object which uses as the aggregate incinerated ash of the target unconfined compressive strength (age 28 days: kgf/cm<sup>2</sup>) 50,100,150,200 for which it asked from drawing 3 , drawing 4 , and Table 12 - 15, And the target unconfined compressive strength which uses as the aggregate what mixed natural \*\*\*\* screenings at a rate of 5:2 to incinerated ash adds and mixes the standard Fe lime shown in Table 11 what mixed 100 kgf/cm<sup>2</sup> (however, thing adjusted to the grain size of M-25 of Table 17). Moreover, grain tone Fe processing material was examined using the concrete recycled aggregate (RM-25) shown in natural \*\*\*\* (M-25) and Table 26 showing in Table 16 as an example of a comparison of the granular aggregate by these cement solidification objects.

[0042] 2-1) Although the California bearing ratio test of California bearing ratio test grain tone Fe processing material was mostly based on the California bearing ratio test of the stabilization mixture of the pavement examining method handbook (Japan Road Association issue), only creation of a specimen carried out as follows using the farmland which can come to hand the present location or near a site from the premise of constructing on a restricted layer with Fe liming soil on a weak subgrade.

\*\* The counts of tamping were 67 each class, it divided into three layers and the addition of tamping and Fe lime stabilizer was made into 6.0(dry weight) %. \*\* Tamping moisture content decided to be based on the moisture content when adding Fe lime stabilizer of the specified quantity to what mixed the coarse aggregate of a surface desiccation saturation state to the farmland of the condition (natural ground) of natural water content.

\*\* Submersion of the care of health of a specimen was continuously carried out from immediately after being immediately after [ tamping ] un-flooded, and tamping, and it made age 28 days the criterion on age the 14th on age the 7th on age the 4th.

[0043] 2-2) When applying the granular aggregate to the general sieve analysis of compaction \*\*\*\* at a granular base course method of construction or mechanical stabilization, since we are anxious about the fall on the strength by grain refining by a compaction etc., specimen sieve analysis after tamping in a California bearing ratio test is performed. So, in this invention, in order to check that grading of aggregate coarse-grain-izes by the agglutination by the ion exchange reaction on the front face of the granular aggregate immediately after a compaction thru/or in its first stage, sieve analysis of the aggregate was performed by the following approaches.

\*\* Unravel the specimen after being immediately after [ tamping ] un-flooded, and the CBR penetration test on age the 4th. After dropping the floor line of concrete 30 times from height of 1.5 morem which put about 1kg into the plastic bag, and bound it with a string, the unraveled sample -- 100-degree C constant temperature -- after washing in cold water the sample which carried out furnace desiccation on 75 micrometers of standard wire sieves and flushing a fine-grained fraction until it becomes fixed mass by desiccation, furnace desiccation is carried out and sieve analysis is performed.

\*\* After extracting about 1kg of furnace dried samples which were dropped from height of 1.5m and unraveled similarly and carrying out distributed processing with distributed equipment by using the saturated solution of hexametaphosphoric acid sodium as a dispersant based on the particle-size-analysis method of geotechnical engineering meeting criteria (JSF T 131-1990) soil, it dried after washing in cold water, and sieve analysis was performed.

[0044] 3) The granular aggregate by the cement solidification object which mixed screenings at a rate of 5:2 to incinerated ash in the test report 27 and Table 28 about the test result of grain tone Fe processing material, the age of consideration 3-1 grain tone Fe processing material, and CBR at sludge incinerated ash (Saga-shi B) and the simple substance list of \*\* (Saga-shi C) The chart of the CBR test result on age zero day of the grain tone Fe processing material made into reinforcing materials, four days, seven days, the 14th, and the 28th is shown. Moreover, when it is i Table 29 with natural \*\*\*\* (M-25) and concrete recycled aggregate (RM-25) as an example of a comparison of the granular aggregate by these cement solidification objects, the CBR test-result chart in the case of the Masa soil simple

substance is shown in a list. However, in the experiment of the example of a comparison, it omitted about age seven days.

[0045] The result of Table 27 - 29 shows the following thing.

**\*\* Although the cement solidification object of incinerated ash was manufactured in quest of the specified mix for every target reinforcement from drawing 3 , drawing 4 , and Table 12 - 15, what was in agreement with profile target reinforcement was made.**

**\*\* the processing material using natural \*\*\*\* -- tamping moisture content -- most -- low -- 8.2% and tamping dry density -- most -- high -- about 2.07 g/cm<sup>3</sup> it is -- the highest tamping moisture content in the processing material using the granular aggregate by the cement solidification object of incinerated ash -- about 23% and tamping dry density -- about 1.59 g/cm<sup>3</sup> it was . Nevertheless, the rise of the moisture content by submersion was about 3.5% at the maximum in 28-day submersion. Embedding of this is carried out completely [ the mixed granular aggregate / in Fe liming soil ], and it is thought that it expresses that it is in the condition of an impermeable layer.**

**\*\* Although the processing material of the Masa soil simple substance of 13.2mm passage part of standard sieves which does not add the coarse aggregate carried out as an example of a comparison again shows high reinforcement, as the farmland used here shows this in Table 4, a plasticity index is because parts for comparatively many coarse aggregate 2mm or more are included with about 25% in respect of grain size, although, as for about 12 and a fine grain part, weathering is progressing.**

[0046] Drawing 12 shows the relation between the CBR reinforcement in each age, and reinforcing materials's target reinforcement from the grain tone Fe processing material California bearing ratio test which makes reinforcing materials the granular aggregate by the cement solidification object which mixed screenings with sludge incinerated ash (Saga-shi B) at a rate of 5:2 to an incinerated ash simple substance and incinerated ash about **\*\* (Saga-shi C)**, and the following thing understands it from a result.

**\*\* The reinforcement effectiveness changes with reinforcement of the cement solidification object of incinerated ash, and expand the difference by advance of the age of processing material.**

**\*\* In proportion to the reinforcement of the cement solidification object to mix, the CBR reinforcement of processing material is increased with advance of the age of processing material. That is, the inclination of the curve showing the relation between the reinforcement of the cement solidification object to mix and the CBR reinforcement of processing material becomes sudden with advance of age so that clearly from drawing 12 .**

**\*\* As an overall trend, advance of the age of processing material changes the inclination by whether the unconfined compressive strength (age 28 days: kgf/cm<sup>2</sup>) of a cement solidification object is 100 or less, or it is 100 or more.**

**\*\* Following, the target reinforcement of the incinerated ash cement solidification object as reinforcing materials of grain tone Fe processing material is 100 kgf/cm<sup>2</sup>. Although it is so desirable that it is above large, the unconfined compressive strength on age the 28th is the dues of incinerated ash from the increase of the maximum, **\*\***, a thing, and an economical field 100 kgf/cm<sup>2</sup> - 150 kgf/cm<sup>2</sup> It is enough if it is a grade.**

**\*\* There is not much big difference at sludge incinerated ash (Saga-shi B) and **\*\* (Saga-shi C)** again. Therefore, if a carbon content (carbon) is below 3.0(weight) %, even if it will not carry out full removal of the carbon, it can be said that it can be equal to practical use enough.**

**\*\* Although effectiveness temporary to improvement of the reinforcement of processing material about the screenings of natural \*\*\*\* is accepted, even if it does not mix natural \*\*\*\*, while required reinforcement is obtained, it is not necessary to use the screenings of natural \*\*\*\* fundamentally also from the purpose of this invention of recycling and using sludge incinerated ash.**

[0047] 3-2) The test reports 20 about coarse-grain-izing of grain tone Fe processing material are immediately after cement solidification \*\*\*\* tone Fe processing material tamping which used sludge incinerated ash (Saga-shi B), and a chart of the sieve analysis of the tamping specimen on age the 4th. Moreover, Table 21 is a result with the same thing of sludge incinerated ash (Saga-shi C), and although Table 22 used natural \*\*\*\* and cement concrete recycled aggregate which were carried out as an example of a comparison, it is a result similarly. This result shows the following thing.

**\*\* For the granular aggregate by the incinerated ash cement solidification object mixed to grain tone Fe processing material, unconfined compressive strength (age 28 days) is 50 kgf/cm<sup>2</sup>. Even if it is the small reinforcement to say, crushing and grain refining by CBR tamping have not occurred.**

**\*\* Here, conversely, the agglutination by the ion exchange reaction of Fe lime stabilizer occurred immediately after mixed tamping thru/or in its contact surface which makes a matrix extremely the front face and Fe liming soil of the granular aggregate in early stages, and granulation (coarse-grain-izing) has occurred.**

[0048] When it had natural \*\*\*\* in drawing 6 and immediately after CBR tamping of the grain tone Fe processing material using the granular aggregate by the cement solidification object of sludge incinerated ash and the grading curve

on age the 4th after tamping were drawing 5 again, the grading curve was shown as a comparison about the grain tone Fe processing material at the time of being in drawing 7 with concrete recycled aggregate further. This shows the following thing.

**\*\* In the grain size after tamping at the time of using the granular aggregate by sludge incinerated ash (Saga-shi B) and the cement solidification object of \*\* (Saga-shi C), both do not almost have a difference.**

**\*\* However, when granulation by agglutination is large and compares the difference of the grain size before a trial, and the grain size on age the 4th with the transmission coefficient of 2.36mm of standard sieves as a whole compared with the conventional natural \*\*\*\* or concrete recycled aggregate, the example of a comparison has the difference of 2 double weakness at about 30% about 18% with the cement solidification object (target unconfined-compressive-strength 50 kgf/cm<sup>2</sup>) of incinerated ash.**

**\*\* In the case of this invention, it is the description that a big difference is in granulation by the agglutination of a fine grain part again. There are whether the granular aggregate of natural \*\*\*\* and concrete being hardly especially different from before a trial by 0.075mm of standard sieves and a difference in the granular aggregate according to an incinerated ash cement solidification object to increasing a little and being 10 - 13%, are 2 - 4%, and big to the agglutination by the ion exchange reaction.**

**\*\* It is possible that the difference of this agglutination is the water retention effectiveness to the grain tone Fe processing material by the incinerated ash cement solidification object. That is, the granular aggregate by the incinerated ash cement solidification object is because grain tone Fe processing material is mixed and manufactured where the water of a saturation state is included in this by the high coefficient of water absorption of 35 - 50% (surface desiccation saturation state) as shown in Table 24.**

**\*\* On the other hand, the water absorption of natural \*\*\*\* of the example of a comparison is 0.82% as shown in Table 16, and the coefficient of water absorption of the concrete recycled aggregate shown in Table 26 is also at most 7.38%. As shown in Table 12 - 15, it is [ in the target unconfined compressive strength (age 28 days:  $q_u$ =kgf/cm<sup>2</sup>)  $q_{u50}$  / in 310-340, and  $q_{u100}$  ] and by no means small [ the cement content per unit volume of concrete (kg/m<sup>3</sup>) of a cement solidification object / at 520-560, and  $q_{u200}$  ] at 600-650 in 410-450, and  $q_{u150}$ . Therefore, while the content moisture is the source of supply of water indispensable to an ion exchange reaction, the water contains reactant components, such as free lime, and it is possible to be a thing in connection with the reaction mechanism of subsequent Fe lime.**

**[0049] It has checked promoting the reaction mechanism of grain tone Fe processing material by making into reinforcing materials the granular aggregate by the cement solidification object which uses sludge incinerated ash of the low strength of extent inapplicable as a base course ingredient as a raw material, if more independent than the above result. Moreover, while it was used and the very thing could also use that the cement solidification object of this invention was porosity for various applications, when it used as the granular aggregate, it has checked that a coefficient of permeability could be made very small by carrying out embedding of the Fe liming soil for this completely as a matrix.**

**[0050]**

**[Example] Next, the example of this invention is explained.**

**[Example 1] The sludge generated in the manufacture approach Saga sewage purification pin center, large of the cement solidification object which uses sludge incinerated ash as a raw material is dehydrated to about 490% of moisture content. Desiccation of the post heating style in which this was made to pile up for 3 seconds at the incineration temperature of 820 degrees C using the incineration facility of the Saga sewage purification pin center, large was performed, and the dust collector recovered granularity incinerated ash with a diameter of about 0.7mm at about 2% (carbon) of carbon contents. And mix water with the incinerated ash and cement which were collected the said weight every mostly, it was made to solidify, and the cement solidification object was manufactured.**

**[0051] the place which measured the unconfined compressive strength of this cement solidification object in age 28 days -- about 110 kgf/cm<sup>2</sup> it was . This cement solidification object is about 47% of specific gravity water absorption is about 1.6, compared with natural \*\*\*\* or concrete recycled aggregate, about 2/, it is as light as 3 and water absorption of specific gravity is very as large as about seven to 50 times. Therefore, if this cement solidification object serves as a raw material of the following grain tone processing material, and also serves as substitution of a lapillus etc. using the height of this light weight and water retention and is used for a gland or a stadium, it can offer the good gland of drainage etc.**

**[0052] [Example 2] Mechanical crushing of the cement solidification object manufactured in the manufacture approach above-mentioned example 1 of grain tone processing material is carried out, and it considers as the granular aggregate. In addition, grain refining is carried out so that it may become the range of the coarse aggregate (M-25) of Table 17 about the size range of this granular aggregate. And the impalpable powder of the iron oxide which carries out a**

byproduction at the time of this granular aggregate, slaked lime, and iron manure was mixed at a rate of 5:5:3 by the dry weight ratio, and grain tone processing material was obtained. As for this grain tone processing material, the granular aggregate is already mixed, it can mix with the natural soil of optimum dose, and the rest can be used for base course material etc.

[0053] [Example 3] The grain tone processing material and the Masa soil which were manufactured in the construction approach example 2 of a stabilization method are mixed at a rate of the dry weight ratio 6:4. And piece rate 1m<sup>3</sup> of a stabilization layer The compaction was carried out and it considered as the compaction stabilized base so that the amount of the hit incinerated ash used might be set to about 170kg (dry weight). When the CBR value of this stabilized base was measured, it was about 570% in about 260% and 28 days in four days. In addition, specific gravity was before and after 1.6.

[0054]

[Effect of the Invention] As stated above, according to the cement solidification object which uses sludge incinerated ash concerning this invention concerning this invention as a raw material It is made for the carbon content of sludge incinerated ash to become below 3(weight) %. This sludge incinerated ash and cement Since mixed incinerated ash:cement at a rate of 1:1-1:3, and add the water of optimum dose, it was made to be a weight ratio and to solidify and unconfined compressive strength was made into 100 - 200 kgf/cm<sup>2</sup> (age 28 days), the sludge incinerated ash of the usual sewage disposal plant can be recycled easily, without carrying out special processing.

[0055] Moreover, since Fe lime system stabilizer which becomes the mixture of the granular aggregate which crushed the above-mentioned cement solidification object, and natural soil from the impalpable powder and slaked lime of an iron oxide was mixed according to the grain tone processing material concerning this invention, sludge incinerated ash can be used in large quantities.

[0056] Furthermore, since a base course is laid by the above-mentioned grain tone processing material and it was made for each granular aggregate to be in the condition that embedding was carried out with Fe lime system processing soil, after a compaction according to the stabilization method concerning starting-this invention invention The reinforcement (especially early age strength) can be increased sharply, without becoming usable as base course material and moreover spoiling the waterproof nature and buffer nature of a processing layer, even if it is not the thing of high intensity so much as the granular aggregate.

[0057]

[Table 1]

下水汚泥焼却灰（佐賀市A）を用いたFe石灰処理土のCBR強度

混 合 土		混合土に対する 重Fe石灰処理率 (%)	乾燥密度 (g/cm <sup>3</sup> )			C B R (%)	
用 土 (%)	焼却灰 (%)		含 水 比 ( % )			4 日	14 日
			直 後	4 日	14 日		
100	0	6.5	— 9.4	1.804 17.6	1.821 17.3	110.2	192.8
95	5	6.5	— 9.2	1.807 21.4	1.603 21.6	58.4	81.8
90	10	6.5	— 8.9	1.476 25.6	1.460 26.5	43.3	60.6
80	20	6.5	— 8.3	1.261 35.7	1.247 37.2	32.8	38.8
60	40	6.5	— 7.1	1.006 50.8	1.001 44.2	7.3	7.7

（ただし、ここでの用土は背振山系のまさ土を用いた）

[0058]

[Table 2]

下水汚泥焼却灰（佐賀市A）を用いたセメント処理土のCBR強度

混 合 土		セメント比 (%)	乾燥密度(g/cm <sup>3</sup> ) 含水比(%)		C B R (%)
用 土 (%)	焼却灰 (%)		直 後	4 日	
100	0	7	— 8.5	1.864 14.7	360.2
90	10	7	— 8.0	1.497 24.9	48.2
80	20	7	— 7.6	1.295 33.5	24.5

[0059]

[Table 3]

下水汚泥焼却灰（佐賀市A）の成分分析結果・単位：重量（%）

試 料 No	T. Fe	SiO <sub>2</sub>	CaO	MnO	MgO	P <sub>2</sub> O <sub>5</sub>	Cr <sub>2</sub> O <sub>3</sub>
96-10-8	9.78	28.51	9.14	0.28	2.82	9.94	0.06

試 料 No	Al <sub>2</sub> O <sub>3</sub>	TiO <sub>2</sub>	Na <sub>2</sub> O	K <sub>2</sub> O	C	pH
96-10-8	16.10	0.75	1.00	0.86	8.53	7.5

[0060]

[Table 4]

用土（背振山系のまさ土）の物理的性質

対 象 土	粒子密度 (g/cm <sup>3</sup> )	粒 度 組 成 ( % )			液性限界 (%)	塑性限界 (%)	塑性指数 (%)
		砂 分	シルト分	粘土分			
まさ土（背振山系）	2.689	73.0	13.1	13.9	37.7	26.1	11.6

[0061]

[Table 5]

用土（背振山系のまさ土）の化学的組成・単位：重量（%）

対象土	SiO <sub>2</sub>	Al <sub>2</sub> O <sub>3</sub>	Fe <sub>2</sub> O <sub>3</sub>	MgO	CaO	Na <sub>2</sub> O	K <sub>2</sub> O	TiO <sub>2</sub>	その他	合 計
まさ土 (背振山系)	67.7	18.4	4.7	0.8	1.6	1.7	3.9	0.6	0.6	100

[0062]

[Table 6]

下水汚泥焼却灰（佐賀市A）を電気炉で 800℃、60分間焼却処理した場合の成分分析結果・単位：重量（%）

試 料 No	T. Fe	SiO <sub>2</sub>	CaO	MnO	MgO	P <sub>2</sub> O <sub>5</sub>	Cr <sub>2</sub> O <sub>3</sub>
97-4-3	4.30	31.75	12.19	0.48	3.33	20.91	0.01

試 料 No	Al <sub>2</sub> O <sub>3</sub>	TiO <sub>2</sub>	Na <sub>2</sub> O	K <sub>2</sub> O	C	pH
97-4-3	20.03	1.12	1.00	0.96	0.07	7.2

[0063]

[Table 7]

電気炉で燃焼処理した下水汚泥焼却灰の添加がPe石灰処理土の強度に及ぼす影響

混 合 土		割合に対する 単Fe添加率 (%)	乾燥密度(g/cm <sup>3</sup> ) 含水比 (%)		C B R (%)
用 土 (%)	焼却灰 (%)		直 後	4 日	
100	0	0	— 10.0	1.873 14.0	15.0
100	0	6.5	— 9.4	1.866 13.7	109.2
95	5 電焼処理	6.5	— 8.9	1.695 18.6	119.6
95	5 熱処理	6.5	— 9.1	1.685 20.0	19.7

[0064]

[Table 8]

現有施設の運転方法の改善によるカーボンの燃焼除去試料「下水汚泥焼却灰（佐賀市B）」の成分分析結果・単位：重量（％）

試 料 No	T.Fe	SiO <sub>2</sub>	CaO	MnO	MgO	P <sub>2</sub> O <sub>5</sub>	Cr <sub>2</sub> O <sub>3</sub>
97-5-2	3.61	39.34	8.47	0.13	4.55	17.59	<0.01

試 料 No	Al <sub>2</sub> O <sub>3</sub>	TiO <sub>2</sub>	Na <sub>2</sub> O	K <sub>2</sub> O	C	pH
97-5-2	17.12	0.93	1.14	1.54	2.28	7.6

[0065]

[Table 9]

下水汚泥焼却灰（佐賀市B）の添加がPe石灰処理土の強度に及ぼす影響

混 合 土		割合に対する 単Fe添加率 (%)	乾燥密度(g/cm <sup>3</sup> ) 含水比 (%)		C B R (%)
用 土 (%)	焼却灰 (%)		直 後	4 日	
100	0	6.5	— 11.3	1.848 14.4	129.4
95	5	6.5	— 15.2	1.752 17.4	91.2
90	10	6.5	— 19.1	1.635 21.1	62.0

[0066]

[Table 10]

ポリ塩化鉄等の適用でカーボンの燃焼除去を図った下水汚泥焼却灰（佐賀市C）の成分分析結果・単位：重量（％）

試 料 No	T.Fe	SiO <sub>2</sub>	CaO	MnO	MgO	P <sub>2</sub> O <sub>5</sub>	Cr <sub>2</sub> O <sub>3</sub>
7/3 供試料	11.75	27.35	12.50	0.34	2.57	17.29	<0.01

試 料 No	Al <sub>2</sub> O <sub>3</sub>	TiO <sub>2</sub>	Na <sub>2</sub> O	K <sub>2</sub> O	C	pH
7/3 供試料	21.23	1.24	0.73	0.92	0.21	9.3

[0067]

[Table 11]

標準Fe石灰（安定材）の化学分析結果・単位：質量（％）

記号	Fe <sub>2</sub> O <sub>3</sub>	SiO <sub>2</sub>	Ca(OH) <sub>2</sub>	MnO	Al <sub>2</sub> O <sub>3</sub>	TiO <sub>2</sub>	C	pH
標準Fe石灰	23.7	0.58	73.3	0.2	0.01	0.71	0.09	12.6

[0068]

[Table 12]

下水汚泥焼却灰（佐賀市B）の単体のセメント固化物の性状

資料No.	焼却灰 (kg)	SC (kg)	水 (kg)	セメント (kg)	C/W	W/C (%)	合計重量 (t/㎡)	一軸圧縮強さ (kgf/㎡)
B-1	541.7	—	668.1	334.1	0.5	200.0	1.543	24.1
B-2	519.8	—	641.0	448.7	0.7	142.9	1.610	59.5
B-3	485.9	—	621.2	559.1	0.9	111.1	1.648	118.5
B-4	449.4	—	599.2	659.1	1.1	90.9	1.708	165.0
B-5	382.0	—	547.5	821.2	1.5	66.7	1.751	280.0
B-6	335.0	—	507.1	1014.1	2.0	50.0	1.859	434.5

[0069]

[Table 13]

下水汚泥焼却灰（佐賀市B）：山砕スクリーニングスを5：2  
の割合で混合した材料のセメント固化物の性状

資料No.	焼却灰 (kg)	SC (kg)	水 (kg)	セメント (kg)	C/W	W/C (%)	合計重量 (t/㎡)	一軸圧縮強さ (kgf/㎡)
B-13	502.5	201.0	619.8	309.9	0.5	200.0	1.633	23.5
B-14	468.8	187.5	593.8	415.6	0.7	142.9	1.666	52.5
B-15	449.4	179.5	578.2	520.4	0.9	111.1	1.728	109.5
B-16	417.5	167.0	551.1	606.2	1.1	90.9	1.742	170.5
B-17	367.3	146.9	514.2	771.3	1.5	66.7	1.800	301.5
B-18	314.4	125.8	482.1	984.2	2.0	50.0	1.887	404.0

[0070]

[Table 14]

下水汚泥焼却灰（佐賀市B）：山砕スクリーニングスを5：2  
の割合で混合した材料のセメント固化物の性状

資料No.	焼却灰 (kg)	SC (kg)	水 (kg)	セメント (kg)	C/W	W/C (%)	合計重量 (t/㎡)	一軸圧縮強さ (kgf/㎡)
B-13	502.5	201.0	619.8	309.9	0.5	200.0	1.633	23.5
B-14	468.8	187.5	593.8	415.6	0.7	142.9	1.666	52.5
B-15	449.4	179.5	578.2	520.4	0.9	111.1	1.728	109.5
B-16	417.5	167.0	551.1	606.2	1.1	90.9	1.742	170.5
B-17	367.3	146.9	514.2	771.3	1.5	66.7	1.800	301.5
B-18	314.4	125.8	482.1	984.2	2.0	50.0	1.887	404.0

[0071]

[Table 15]

下水汚泥焼却灰（佐賀市C）：山砕スクリーニングスを5：2  
の割合で混合した材料のセメント固化物の性状

資料No.	焼却灰 (kg)	SC (kg)	水 (kg)	セメント (kg)	C/W	W/C (%)	合計重量 (t/㎡)	一軸圧縮強さ (kgf/㎡)
C-13	530.6	212.2	636.7	318.3	0.5	200.0	1.698	35.0
C-14	496.0	198.4	595.3	416.7	0.7	142.9	1.706	77.0
C-15	458.4	183.4	574.5	517.8	0.9	111.0	1.734	145.0
C-16	431.7	172.7	561.2	617.3	1.1	90.9	1.783	214.0
C-17	381.9	152.8	509.2	763.8	1.5	66.7	1.808	350.5
C-18	314.4	125.8	480.8	984.2	2.0	49.9	1.885	456.5

[0072]

[Table 16]

比較例として用いた天然山砕石（M-25）の骨材性状

骨材の種類	比 重			吸水率 (%)	すりへり量 (%)	耐性指数 (P I)	最大乾燥率 (%)	最大乾燥率 (g/㎡)	修正CBR (%)
	表 乾	飽 乾	見かけ						
天然山砕 (M-25)	2.842	2.819	2.886	0.82	23.1	3.5	6.7	2.295	88.0

[0073]  
[Table 17]

粒調Fe処理路盤材の粒度範囲の計算

配合率 (%)	組 骨 材		自然土 (まき土)	各骨材のふるい目目の配合率			合 成 粒 度			粒度範囲
	M-25	C-30		M-25	C-30	まさ土	M-25 まき土	C-30 まき土	平 均	
37.5		100.0		40.0	40.0	60.0		100.0	100.0	100
31.5	100.0	97.6		40.0	39.0	60.0	100.0	99.0	100.0	90 ~ 100
26.5	97.5	86.0		39.0	34.4	60.0	99.0	94.4	98.7	78 ~ 100
19.0	80.0	70.0		32.0	28.0	60.0	92.0	88.0	90.0	70 ~ 100
13.2	70.0	45.0	100.0	28.0	18.0	60.0	88.0	78.0	83.0	63 ~ 100
4.75	47.5	30.0	95.2	19.0	12.0	57.1	78.1	69.1	72.6	45 ~ 85
2.36	35.0	17.5	78.5	14.0	7.0	47.1	61.1	54.1	57.6	37 ~ 77
1.18	28.0	12.0	57.0	11.2	4.8	34.2	45.4	39.0	42.2	27 ~ 62
0.425	20.0	6.0	32.6	8.0	2.4	18.6	27.6	22.0	24.8	15 ~ 40
0.075	8.0	2.0	13.5	3.2	0.8	8.1	11.3	8.9	10.1	7 ~ 20

[0074]  
[Table 18]

まさ土と標準山砂による粒調Fe処理材における粒状骨材の混入率と合成粒度

ふるいの 目の開き (mm)	用 土 及 び 骨 材			合 成 粒 度 - 0 %			合 成 粒 度 - 20 %				合 成 粒 度 - 40 %			
	自然土 (まき土)	標準山砂 (M-25)	安定材 (FeBR)	自然土 94.0	安定材 (FeBR) 6.0	合成粒度	まさ土 75.2	M-25 18.8	安定材 (FeBR) 6.0	合成粒度	まさ土 56.4	M-25 37.6	安定材 (FeBR) 6.0	合成粒度
53.0														
37.5														
31.5	100	100	100	94.0	6.0	100	75.2	18.8	6.0	100	56.4	37.6	6.0	100
26.5	100	97.5	100	94.0	6.0	100	75.2	18.3	6.0	99.5	56.4	36.7	6.0	99.1
19.0	100	80.0	100	94.0	6.0	100	75.2	15.0	6.0	96.2	56.4	30.1	6.0	92.5
13.2	100	70.0	100	94.0	6.0	100	75.2	13.2	6.0	94.4	56.4	26.3	6.0	88.7
4.75	95.2	47.5	100	89.5	6.0	95.5	71.6	8.9	6.0	86.5	53.7	17.9	6.0	77.6
2.36	78.5	35.0	100	73.8	6.0	79.8	58.0	6.6	6.0	71.6	44.3	13.2	6.0	63.5
1.18	57.0	28.0	100	53.6	6.0	59.6	42.9	5.3	6.0	54.2	32.1	10.5	6.0	48.6
0.425	32.6	20.0	100	30.6	6.0	36.6	24.5	3.8	6.0	34.3	18.4	7.5	6.0	31.9
0.075	13.5	8.0	100	12.7	6.0	18.7	10.2	1.5	6.0	17.7	7.6	3.0	6.0	16.6

[0075]  
[Table 19]

まさ土と標準山砂による粒調 $\text{Fe}$ 処理材における粒状骨材の混入率と合成粒度

ふるいの 目の開き (mm)	合 成 粒 度 - 60 %				合 成 粒 度 - 80 %				合 成 粒 度 - 100 %		
	まさ土 37.6	M-25 56.4	安定材 ( $\text{Fe}$ 処理) 6.0	合成粒度	まさ土 18.8	M-25 75.2	安定材 ( $\text{Fe}$ 処理) 6.0	合成粒度	自然土 94.0	安定材 ( $\text{Fe}$ 処理) 6.0	合成粒度
53.0											
37.5											
31.5	37.6	56.4	6.0	100	18.8	75.2	6.0	100	94.0	6.0	100
26.5	37.6	55.0	6.0	98.6	18.8	73.3	6.0	98.1	91.7	6.0	97.7
19.0	37.6	45.1	6.0	88.7	18.8	60.2	6.0	85.0	75.2	6.0	81.2
13.2	37.6	39.5	8.0	83.1	18.8	52.6	6.0	77.4	65.8	6.0	71.8
4.75	35.8	26.8	6.0	68.6	17.9	35.7	6.0	59.6	44.7	6.0	50.7
2.36	29.5	19.7	6.0	55.2	14.8	26.3	6.0	47.1	32.9	6.0	38.9
1.18	21.4	15.8	6.0	43.2	10.7	21.1	6.0	37.8	26.3	6.0	32.3
0.425	12.6	11.3	6.0	29.9	6.1	15.0	6.0	27.1	18.8	6.0	24.8
0.075	5.1	4.5	6.0	15.6	2.5	6.0	6.0	14.5	7.5	6.0	13.5

[0076]  
[Table 20]下水汚泥焼却灰（佐賀市B）のセメント固化物による粒状骨材を用いた粒調 $\text{Fe}$ 処理材のC B R突固め後の供試体のふるい分け試験結果

		通 過 質 量 百 分 率 ( % )										
		26.5mm	19.0mm	13.2mm	9.5mm	4.75mm	2.36mm	1.18mm	0.600mm	0.425mm	0.150mm	0.075mm
qu=50 kgf/cm <sup>2</sup>	合成粒度	100.0	94.8	92.2	89.5	83.1	68.9	52.9	39.7	34.8	23.7	18.1
	突固め後	#0	100.0	94.4	86.0	79.0	68.5	50.8	36.6	25.0	11.9	9.5
		#4	100.0	85.8	75.2	68.1	54.7	38.5	25.4	15.0	11.1	3.5
qu=100 kgf/cm <sup>2</sup>	合成粒度	100.0	94.7	92.0	89.3	82.9	68.7	52.8	39.6	34.7	23.7	19.0
	突固め後	#0	100.0	90.2	81.4	75.9	62.9	47.4	33.8	22.5	18.4	9.7
		#4	100.0	80.4	68.9	63.5	51.1	36.0	23.6	14.1	10.9	4.0
qu=150 kgf/cm <sup>2</sup>	合成粒度	100.0	94.5	91.7	88.9	82.4	68.2	52.4	39.4	34.5	23.6	18.9
	突固め後	#0	100.0	90.6	83.3	76.1	62.5	46.9	33.0	20.9	17.2	9.8
		#4	100.0	88.0	78.6	72.5	58.7	42.2	28.5	17.1	13.6	6.0
qu=200 kgf/cm <sup>2</sup>	合成粒度	100.0	94.7	92.0	89.3	82.9	68.6	52.7	39.6	34.7	23.7	19.0
	突固め後	#0	100.0	81.3	64.0	56.7	45.0	34.9	25.9	18.0	15.4	9.5
		#4	100.0	82.9	69.8	62.8	52.3	39.9	26.0	16.9	12.1	6.7
qu=100 (+SC) kgf/cm <sup>2</sup>	合成粒度	100.0	94.6	91.9	89.1	82.7	68.4	52.6	39.5	34.6	23.6	18.9
	突固め後	#0	100.0	91.4	85.9	80.0	68.3	53.4	39.0	27.1	22.7	13.3
		#4	100.0	81.0	72.6	68.8	54.8	38.6	25.9	14.8	11.5	6.2

[0077]  
[Table 21]

下水汚泥焼却灰（佐賀市C）のセメント固化物による粒状骨材を用いた粒調Fe処理材のC B R突固め後の供試体のふるい分け試験結果

			通過質量百分率（％）										
			26.5mm	19.0mm	13.2mm	9.5mm	4.75mm	2.36mm	1.18mm	0.600mm	0.425mm	0.150mm	0.075mm
qu= 50 kgf/cm <sup>2</sup>	合成粒度		100.0	94.8	92.2	89.6	83.2	69.0	53.0	39.7	34.8	23.8	19.1
	突固め後	φ0	100.0	91.0	83.1	77.7	64.3	49.2	35.2	24.3	20.3	11.9	9.9
		φ4	100.0	78.8	70.3	64.2	50.0	34.2	22.4	13.7	10.8	3.8	2.0
qu=100 kgf/cm <sup>2</sup>	合成粒度		100.0	94.6	91.9	89.1	82.7	68.4	52.6	39.5	34.6	23.6	18.9
	突固め後	φ0	100.0	90.3	84.0	78.5	67.2	52.5	38.6	26.5	22.6	14.7	13.3
		φ4	100.0	86.2	78.6	69.1	56.2	39.9	26.8	16.0	12.6	5.0	3.1
qu=150 kgf/cm <sup>2</sup>	合成粒度		100.0	94.4	91.6	88.8	82.3	68.1	52.3	39.3	34.4	23.5	18.8
	突固め後	φ0	100.0	93.8	86.1	80.6	68.8	53.6	38.0	25.0	21.1	12.6	10.8
		φ4	100.0	85.5	77.7	72.0	58.5	42.3	28.6	17.6	14.3	6.5	4.2
qu=200 kgf/cm <sup>2</sup>	合成粒度		100.0	94.4	91.6	88.7	82.2	68.0	52.9	39.2	34.4	23.4	18.8
	突固め後	φ0	100.0	95.9	88.5	82.6	71.0	56.9	42.6	30.0	25.8	16.4	14.0
		φ4	100.0	84.5	76.1	69.5	55.0	39.1	25.5	15.3	12.3	5.5	3.4
qu=100 (+SC) kgf/cm <sup>2</sup>	合成粒度		100.0	94.5	91.8	89.0	82.5	68.3	52.5	39.4	34.5	23.6	18.9
	突固め後	φ0	100.0	95.2	89.3	84.0	72.9	58.7	44.0	31.0	26.6	16.5	14.0
		φ4	100.0	83.8	78.1	71.8	56.8	40.6	28.9	16.8	13.5	8.2	4.3

[0078]

[Table 22]

比較例として天然山砂（M-25）及びコンクリート再生骨材（RM-25）を用いた粒調Fe処理材のC B R突固め後の供試体のふるい分け試験結果

			通 過 質 量 百 分 率 ( % )										
			26.5mm	19.0mm	13.2mm	9.5mm	4.75mm	2.36mm	1.18mm	0.600mm	0.425mm	0.150mm	0.075mm
山 砂 M-25	合成粒度		100.0	92.3	88.4	84.6	77.1	63.1	48.7	38.7	32.2	21.7	17.2
	突固め後	φ0	100.0	91.1	80.3	74.5	64.9	52.5	40.5	29.7	26.0	15.0	11.1
		φ4	100.0	84.5	72.0	67.3	54.1	43.8	34.8	26.6	23.8	17.0	13.2
コンクリート 再生 RM-25	合成粒度		100.0	93.0	89.5	86.0	78.8	64.8	49.9	37.6	33.0	22.3	17.7
	突固め後	φ0	100.0	91.8	82.9	77.1	66.1	54.0	41.5	27.7	23.5	13.5	9.6
		φ4	100.0	85.6	76.8	69.6	54.9	43.2	32.0	22.7	19.7	12.1	9.8

[0079]

[Table 23]

まさ土と標準山砂による粒調Fe処理材における粒状骨材の混入率と材令4日水浸のC B Rと透水試験結果（混入率および配合率は乾燥重量）

骨材混入率 (%)	配 合 率 ( % )			含 水 比 ( % )		乾燥密度 (g/cm <sup>3</sup> )	C B R (%)	透 水 係 数 (cm/s)
	まさ土	標準骨材	Fe石灰	直 後	水浸後			
0	94.0	—	6.0	11.7	14.9	1.928	203.8	$5.5 \times 10^{-1}$
20	75.2	18.8	6.0	10.4	13.2	2.018	248.8	$4.0 \times 10^{-1}$
40	56.4	37.6	6.0	9.0	12.4	2.099	281.8	$8.4 \times 10^{-1}$
60	37.6	56.4	6.0	7.5	11.5	2.149	171.5	$8.7 \times 10^{-1}$
80	18.8	75.2	6.0	6.1	11.2	2.187	89.4	$2.8 \times 10^{-1}$
100	—	100.0	6.0	4.7	11.4	2.164	46.5	$8.0 \times 10^{-1}$

[0080]

[Table 24]

焼却灰セメント固化物による骨材の比重及び吸水量

材料の種類	焼却灰(佐賀市B)					焼却灰(佐賀市C)				
	50	100	150	200	100-SC	50	100	150	200	100-SC
表乾比重	1.624	1.609	1.599	1.744	1.753	1.702	1.695	1.723	1.733	1.786
吸水率(%)	48.0	47.3	38.9	34.6	41.6	48.2	47.3	39.4	38.3	37.5

(ただし材料の種類別の示す数字は目標一軸強度を、SCは天然山砕スクリーニングスを示す)

[0081]

[Table 25]

使用材料の比重による容積比調整の例

使用材料	(佐賀市B) 固化物 $q_u=50$				天 然 山 砕			
	まさ土	粗骨材	Fe石灰	計	まさ土	粗骨材	Fe石灰	計
骨材配合率(a)	56.4	37.6	6.0	230.2	58.4	37.6	6.0	276.0
比重 (b)	2.669	1.624	3.105		2.669	2.842	3.105	
(a)×(b) (c)	150.5	61.1	18.6		150.5	106.9	18.6	
修正配合率 $\left[\frac{(c)}{a} \times 100\right]$	65.4	26.5	8.1		54.5	38.7	6.7	

[0082]

[Table 26]

比較例として用いたコンクリート再生骨材(RM-5)の骨材性状

骨 材 の 種 類	比 重			吸 水 率 (%)	すりへり量 (%)	塑性指数 (P.I.)	含水率 (%)	最大乾燥密度 (g/cm <sup>3</sup> )	修正CBR (%)
	表 乾	飽 乾	見かけ						
コンクリート再生骨材 (RM-25)	2.432	2.270	2.742	7.38	29.7	N.P.	11.4	1.873	92.3

[0083]

[Table 27]

下水汚泥焼却灰(佐賀市B)のセメント固化物を補強材とする  
粒調Fe処理材のCBR試験結果

目標 $q_u$	試験値 $q_u$ (kgf)	養 生 日 数	配合率(%)			含 水 比	乾燥密度	CBR値
			まさ土	固化物	Fe石灰			
50	47.3	0 日	65.8	26.1	8.1	22.2	—	52.6
		4 日					24.0	219.0
		7 日					23.7	281.0
		14 日					24.3	338.5
		28 日					24.1	432.1
100	113.3	0 日	65.3	26.6	8.1	19.1	—	85.4
		4 日					22.9	269.5
		7 日					22.5	352.6
		14 日					22.9	451.3
		28 日					23.0	572.1
150	162.3	0 日	64.4	27.6	8.0	20.6	—	73.7
		4 日					22.9	284.6
		7 日					22.5	379.1
		14 日					22.5	516.4
		28 日					22.7	599.3
200	215.3	0 日	65.2	26.7	8.1	18.5	—	109.5
		4 日					20.9	298.2
		7 日					20.6	401.3
		14 日					21.0	540.9
		28 日					21.2	603.0
100	91.3	0 日	64.9	27.1	8.0	18.9	—	120.4
		4 日					21.9	308.8
		7 日					22.0	359.1
		14 日					22.4	528.0
		28 日					22.5	529.3

[0084]

[Table 28]

下水汚泥焼却灰（佐賀市C）のセメント固化物を補強材とする  
粒調Fe処理材のCBR試験結果

目標 qu	試験値 qu(平均)	養生 日数	配合率(%)			含水比		乾燥密度 (g/cm <sup>3</sup> )	CBR値 (%)
			まさ土	固化物	Fe石灰	直後	水浸		
50	57.3	0日	66.0	25.9	8.1	22.9	—	1.574	72.3
		4日					24.2	1.583	220.8
		7日					24.8	1.628	315.0
		14日					24.6	1.580	376.6
		28日					24.7	1.596	491.2
100	106.8	0日	64.9	27.1	8.0	19.1	—	1.661	96.3
		4日					21.4	1.628	283.9
		7日					21.3	1.632	343.9
		14日					21.6	1.624	513.9
		28日					21.6	1.639	575.2
150	156.8	0日	64.2	27.9	7.9	20.6	—	1.631	112.0
		4日					22.5	1.624	292.3
		7日					22.3	1.647	382.3
		14日					22.6	1.629	542.3
		28日					23.1	1.616	631.4
200	200.2	0日	64.0	28.1	7.9	18.5	—	1.658	124.1
		4日					21.2	1.660	312.5
		7日					21.2	1.592	393.4
		14日					21.6	1.642	561.2
		28日					21.8	1.650	651.8
100	102.0	0日	64.6	27.4	8.0	20.0	—	1.667	84.7
		4日					21.9	1.660	254.4
		7日					21.7	1.669	393.1
		14日					22.2	1.641	507.4
		28日					22.7	1.641	586.1

[0085]

[Table 29]

比較例（天然山砕、再生骨材を補強材とする場合および補強材を  
用いない場合）のCBR試験結果

材 料 名	養生 日数	配合率(%)			含水比		乾燥密度 (g/cm <sup>3</sup> )	CBR値 (%)
		まさ土	固化物	Fe石灰	直後	水浸		
標準山砕 M-25	0日	54.6	38.7	6.7	8.2	—	2.094	70.5
	4日					10.6	2.079	238.5
	7日					—	—	—
	14日					10.6	2.084	428.8
	28日					11.0	2.033	545.3
コンクリート 再生材 RM-25	0日	57.8	35.1	7.1	11.3	—	1.955	64.2
	4日					13.2	1.947	184.7
	7日					—	—	—
	14日					12.8	1.946	381.4
	28日					12.7	1.956	508.4
まさ土 (13mm以下)	0日	93.1	—	6.9	9.3	—	1.926	60.90
	4日					11.7	1.934	163.5
	7日					—	—	—
	14日					12.0	1.924	400.0
	28日					11.7	1.901	498.4

[Translation done.]

## \* NOTICES \*

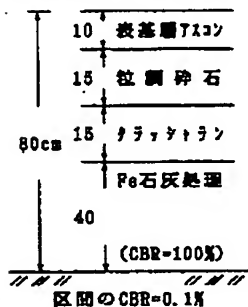
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## DRAWINGS

## [Drawing 1]

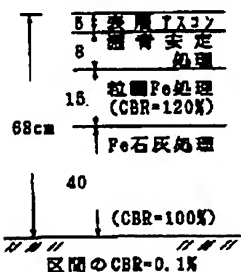
(設計交通量区分=B交通)



Fe石灰工法の標準的な舗装構成の例

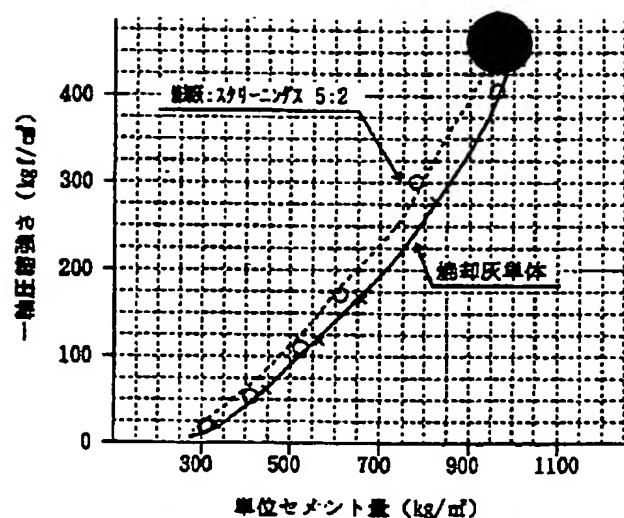
## [Drawing 2]

(設計交通量区分=B交通)



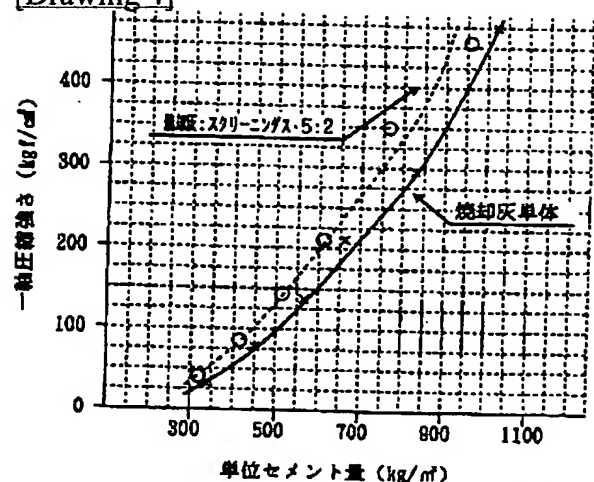
粒調Fe処理材を路盤に適用する舗装構成の例

## [Drawing 3]



下水汚泥焼却灰（佐賀市B）のセメント固化物の  
単位セメント量と一軸圧縮強さの関係

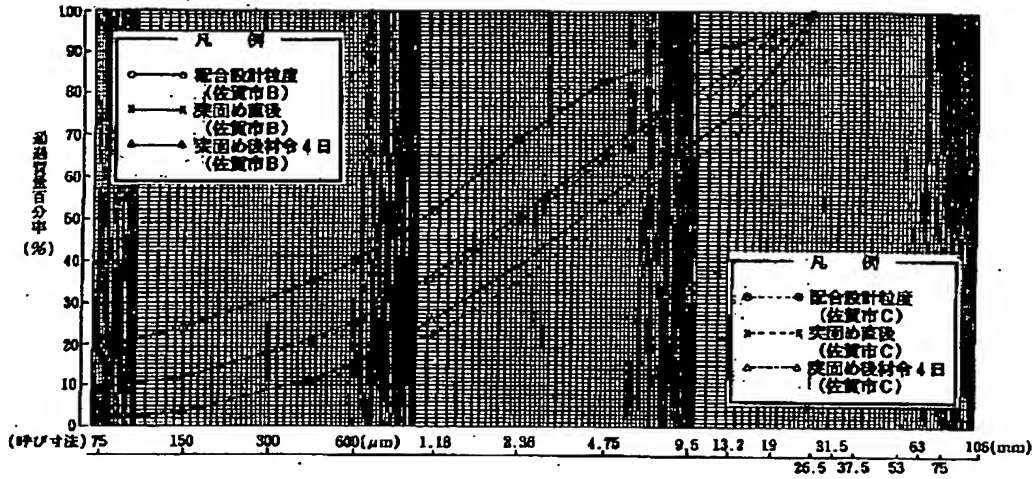
[Drawing 4]



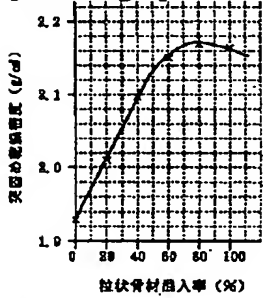
下水汚泥焼却灰（佐賀市C）のセメント固化物の  
単位セメント量と一軸圧縮強さの関係

[Drawing 5]

下水用肥粒灰のセメント固化体（一軸圧縮強さ=50kgf/cm<sup>2</sup>、材令日）  
による粒状骨材を用いた粒面Fe<sub>2</sub>O<sub>3</sub>の粒皮変化

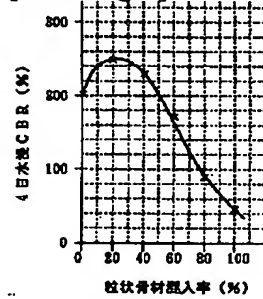


[Drawing 8]



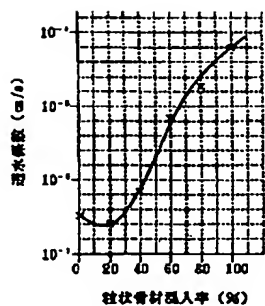
まさ土と標準山砂による乾固Fe<sub>2</sub>O<sub>3</sub>  
処理材における粒状骨材混入率と  
練固め密度の関係

[Drawing 9]



まさ土と標準山砂による乾固Fe<sub>2</sub>O<sub>3</sub>  
処理材における粒状骨材混入率と  
CBRの関係

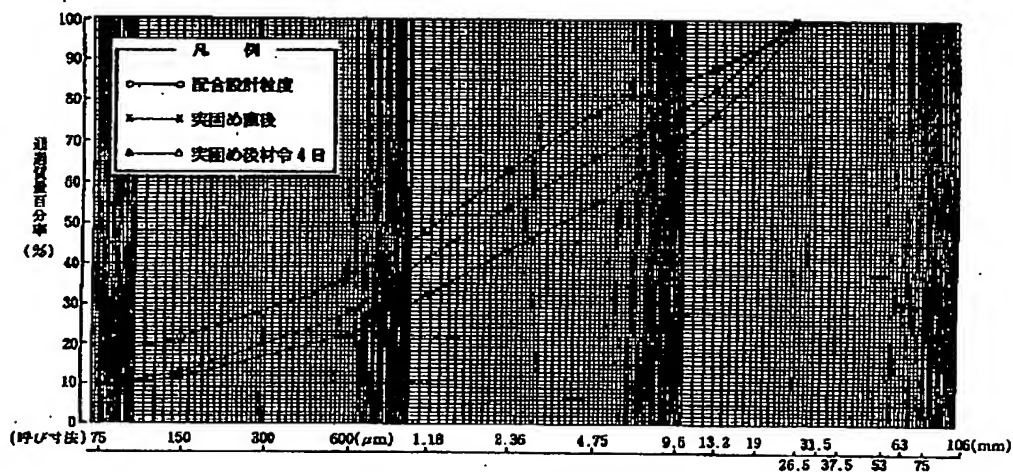
[Drawing 10]



まき土と御幸山砂による粒間Fe  
処理材における粒状骨材透入率と  
透水係数の関係

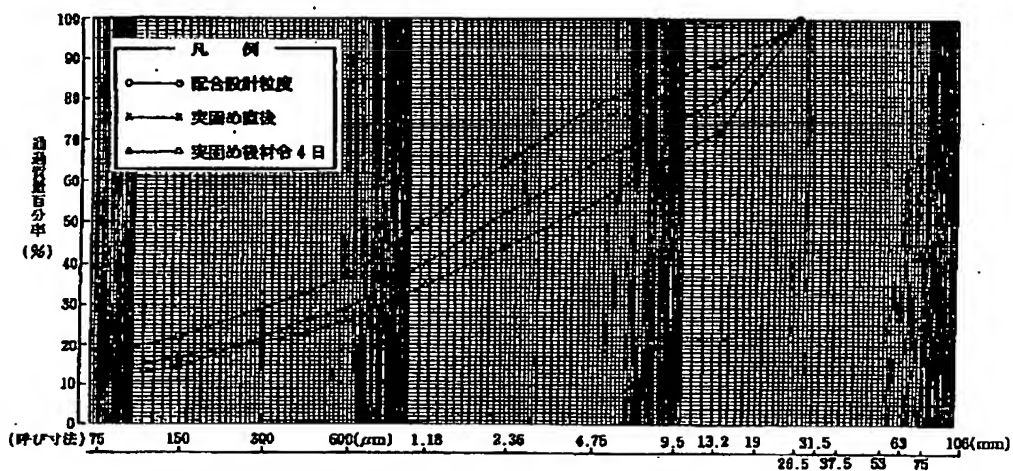
[Drawing 6]

天然山砂 (M-25) を用いた粒間Fe処理材の粒度変化



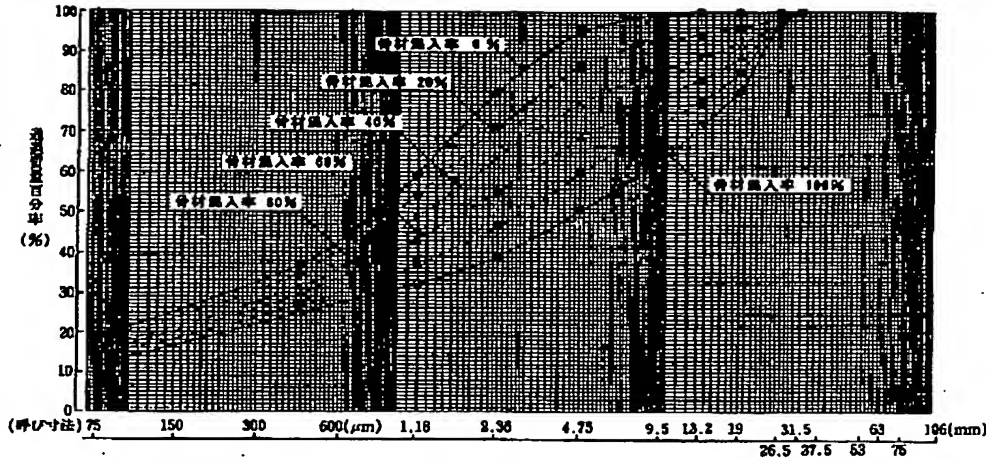
[Drawing 7]

コンクリート再生骨材 (RM-25) を用いた粒間Fe処理材の粒度変化

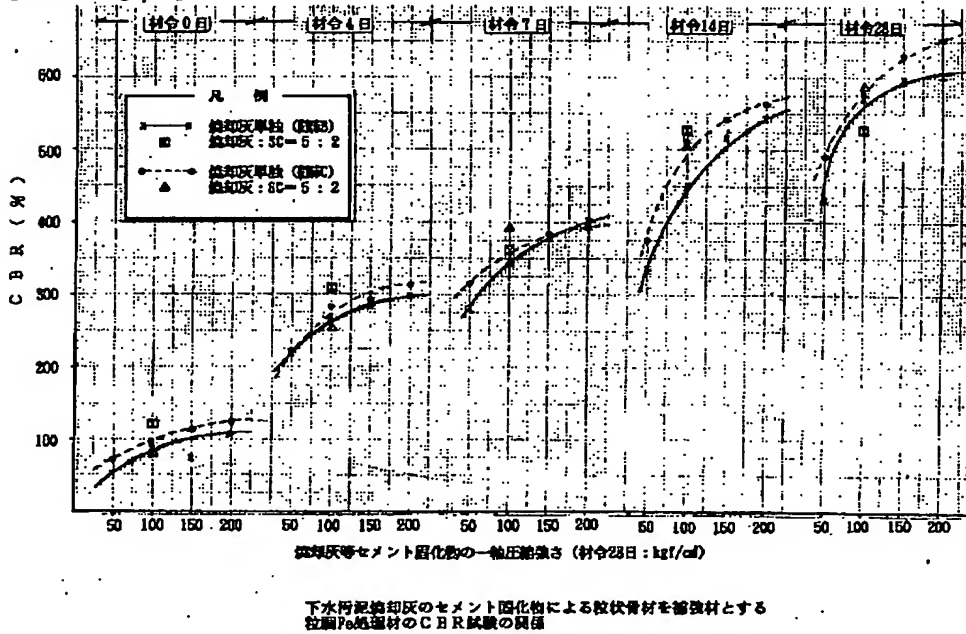


[Drawing 11]

まさ土と標準山砂による粒状Fe処理剤による粒状骨材の混入率と合成粒度曲線



[Drawing 12]



[Translation done.]